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12NOV02 E768844-1 D02820
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Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

The Patent Office
Cardiff Road
Newport
South Wales
NP10 8QQ

1. Your reference — P03773GB

2. Patent application number *(The Patent Office will fill in this part)* — 0226349.9 — 12 NOV 2002

3. Full name, address and postcode of the or of each applicant *(underline all surnames)* — DUNLOP AEROSPACE LIMITED, Holbrook Lane, Coventry, CV6 4AA, England

   Patents ADP number *(if you know it)* — 075 86266003

   If the applicant is a corporate body, give the country/state of its incorporation — GB

4. Title of the invention — VALVE

5. Name of your agent *(if you have one)*

   "Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)* — LAURENCE SHAW & ASSOCIATES, Metropolitan House, 1 Hagley Road, Edgbaston, Birmingham B16 8TG

   Patents ADP number *(if you know it)* — 13623001

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*
   a) any applicant named in part 3 is not an inventor, or
   b) there is an inventor who is not named as an applicant, or
   c) any named applicant is a corporate body.
   See note (d)) — Yes

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9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	
Description	9
Claim(s)	0
Abstract	0
Drawing(s)	3 only 8

10. If you are also filing any of the following, state how many against each item.

Priority documents	
Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
Request for preliminary examination and search *(Patents Form 9/77)*	
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. I/We request the grant of a patent on the basis of this application.

Signature LAURENCE SHAW & ASSOCIATES Date 12/11/02.

12. Name and daytime telephone number of person to contact in the United Kingdom Edward C Dowler 0121 454 4962

Warning

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Agents ref: P03773GB

VALVE

This invention relates to a valve, more particularly but not exclusively, an air bleed valve for an aircraft gas turbine engine. In the field of gas turbine engines for aircraft, there is frequently a requirement to bleed off compressor air for service purposes such as anti-icing flow. At low engine speeds, the pressure developed by a low pressure stage may be insufficient to provide the flow rate required for such purposes. An adequate flow rate may only be satisfied by the higher pressure stages, e.g. from the second of two stages or the 3rd of 3 or the 7th of 10 and so on. At higher engine speeds, however, both the pressure and the air temperature from the same stage may be too high thereby producing a flow rate which is excessive to requirements. Adequate quantities of bleed air at appropriately lower temperatures at higher engine speeds can typically be obtained from a low pressure compressor stage, e.g. the first of two or three or the third of ten and so on.

When the requirement is for a substantially constant mass flow rate of air to be provided for anti-icing purposes throughout the entire engine speed range, a common method is to adopt two separate valves, one receiving bleed air from a lower pressure compressor stage and the other from a higher pressure stage. The valve receiving air from the lower pressure stage progressively opens with increasing engine speed (since compressor pressure rises with engine speed), until it is fully open at rated engine speed. The valve receiving air from the higher pressure stage typically may progressively close from a fully open position at engine idling speed to a fully closed position at engine rated speed. Each valve may operate independently from the other, any final mixing occurring just prior to delivery to the anti-icing air distribution ducts.

Alternatively, only one valve may be provided which may operate in conjunction with a

pressure regulator.

Valves used in this technology are of the type where the valve element is moved by the pressure of a fluid. Fluid from the higher pressure side of the valve is substantially prevented from leaking to the lower pressure side by the fitting of dry running carbon seals. Alternatively, leakage is completely prevented by use of rolling diaphragms. When bleed air temperatures exceed a certain level, rolling diaphragms cannot be used

It will be appreciated that air drawn through a gas turbine compressor may be heavily contaminated with sand and grit particles ranging in size between may be 1mm across down to fine dry or sticky dust particles one-hundredth of a millimetre across or less.

The current systems described above may typically suffer from two main drawbacks.

Firstly, where valve pistons operate within closely fitting bores, the dry-running piston seals are prone to sticking and jamming due to the constant throughput and building up of contamination.

Secondly, owing to the pressure difference across a valve piston seal commonly used in this technology field, there arises a frictional resistance to the movement of the valve piston which in turn causes the characteristic stick-slip motion typical of this type of sealing arrangement. The frictional resistance to movement is usually proportional to the pressure difference across the seal. The effect of the stick-slip is to reduce the resolution of the valve. i.e. to impair the sensitivity of the response of the valve to a small change in engine speed. A reduction in valve resolution can lead to a valve giving a mass flow performance characteristic outside its required tolerance range.

One object of the present invention is to provide a valve which does not require close valve piston-bore clearances or nominally low-leakage dry running seals. Consequently there are no significant frictional loads opposing the modulating action and no close clearances vulnerable to contamination blockage. A further object is to provide a valve usable under conditions where bleed air temperatures are too high to enable rolling diaphragms to give a satisfactory service life.

According to one aspect of the invention, there is provided a valve having a valve body, two inlet ports for receiving fluid at respective different pressures, an outlet port for delivering said fluid, a valve member mounted for limited movement within said body, and biasing means for biasing said valve member to move to one limit of its movement, said valve member being operable to move in response to the difference in pressure at said first and second ports and in response to said biasing means for causing the valve member to vary the respective contributions of fluid delivered to the outlet port from the inlet ports.

Advantageously, the valve body contains a further movable valve member which is operable for receiving fluid from isolating control means and, in response thereto, for moving to close off one of said inlet ports and for urging the first mentioned valve member to close off the other inlet port.

According to a second aspect of the present invention a valve incorporates a valve modulating element. It is provided with two flow inputs, one from a high pressure compressor stage, the second from a low pressure compressor stage. Both flow sources exhibit a rising pressure characteristic with an increase in engine speed. At engine idling speed, the valve element is urged by a spring to a position which permits full service flow from the high pressure source to a service duct and substantially zero

flow from the low pressure source to the service duct. As engine speed increases, an increasing pressure differential across the valve element develops thereby causing the valve element to move against the spring and to begin to permit flow from the low pressure source to the service duct. At the same time, the flow area which is allowing flow from the high pressure source to the service duct begins to decrease. As engine speed rises further, flow from the high pressure source is progressively shut off whilst flow from the low pressure source increases until at engine rated speed, or other predetermined engine speed, the flow from the high pressure source is substantially cut off and flow from the low pressure source attains its full rated flow through to the service duct.

The flow profiles of the valve element are arranged to give the desired flow throughput with increasing engine speed between the extremes of firstly, full service flow from the high pressure source to the service duct and no flow from the low pressure source to the service duct and, secondly, no flow from the high pressure source to the service duct and full flow from the low pressure source to the service duct.

For a better understanding of the invention and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:

Figure 1 is a sectional elevation of a valve for receiving air from lower and higher pressure compressor stages of a gas turbine engine and delivering such air to an outlet port, the valve being in a first state;

Figures 2, 3 and 4 correspond to Figure 1 but showing the valve in second, third and fourth states respectively;

Figure 5 is a section on the line VV in Figure 1;

Figure 6 is a graph illustrating the variation of engine speed with air pressure from the lower and higher pressure compressor stages and the desired service pressure at the outlet port; and

Figure 7 is a graph illustrating a substantially constant mass flow of air available at the outlet port as engine speed varies, and the respective contributions of the mass flow from the two compressor stages.

The valve 1 of Figure 1 to 5 comprises a valve body 2 bounding a generally cylindrical hollow space 3 in which there are two movable valve members 4 and 5.

The valve member 4 is generally cylindrical and hollow. Near one end 6, there is a partition 7 extending across the cylindrical space 8 within the valve member and supporting a spindle 9. Spindle 9 extends through space 3 and is aligned along the axis 17 thereof. It has first and second portions 10 and 11 of about equal length with the portion 10 being nearer the partition 7. This portion 10 has an outside diameter greater than that of portion 11 and it has a bore 12 formed therein, the bore extending right along the portion 10 from the end near partition 7. Portions 10 and 11 merge one with the other via a short tapered section 15.

The valve member 4 is slidably movable within the space 3 and it has two spaced circumferential slots 20 in each of which there is a sealing ring 21. Preferably, the sealing ring is made of carbon and is a composite ring comprising a split ring 21a and two side-by-side spit rings 21b and 21c between ring 21a and the wall of space 3.

The rear corner end face 22 of valve member 4 is tapered and is engageable with a matching seating surface 23 at which the space 3 merges with a gas port 24. The front corner end face 25 of valve member 4 is also tapered and is able to engage a seating surface 26 defined in a partition section 27 of the space 3 between two further gas ports 28 and 29 respectively. Ports 28 and 29 extend transversely away from the axis 17 and communicate with space 3. The other side, i.e. the port 29 side of partition section 27 also has a tapered seating surface 30.

Within the space 3, partially engaged within the valve member 4, there is the other movable valve member, i.e. the member 5. Member 5 has a rear section 35 which is generally spool shaped and a bullet shaped front portion 36.

The bullet-shaped portion faces a further port 40 which merges with space 3 via a further tapered seating 41 which matches an engaging portion 42 at the base of the bullet-shaped portion.

The rear facing corner 43 of the front of the spool-shaped section of the valve member 5 is tapered so as to be able to engage the seating.

In addition, within the spool shaped portion of the valve member 5, there is a compression spring 60 which is engaged between the rear wall 44 of the valve member 5 and an annular plate 45 fixed to the spindle part 11. The outside of the rear wall 44 is shaped to match the front face 46 of partition 7.

Ports 40 and 28 are coupled to the higher and lower pressure respectively of two compressor stages of a gas turbine engine (not shown). Port 29 is an outlet for service air purposes for example to the ant-icing system of the aircraft (not shown). Port 24 is

connected to a source of high pressure air, for example the aforementioned higher pressure compressor stage, via an isolating controller valve (not shown).

The interior of the valve 5 communicates with space 3 via opening 50. Ports 28 and 29 may have drain ports 51.

Initially, as shown in Figure 1, the engine is running at relatively low speed. The valve is in its rearward position, i.e. to the right in the figure, so that the high pressure stage port 40 is open to the space 3 and to the outlet port 29. The seating is closed by the valve surface at corner 43 so as to seal the lower pressure compressor stage port form the valve.

As the engine speed increases, the pressure of the air from the lower pressure compressor stage builds up in the interior of the valve member 5 and drives it forward to an intermediate valve state shown in Figure 2. Here, air is received and passed to outlet port 29 from both compressor stages. As the engine speed continues to rise, the valve member 5 is driven further forward so that port 40 is closed off and the service air supply is delivered from the low pressure stage alone.

At any stage shown in Figures 1 to 3, air can be delivered via the isolator control to port 24. This drives the valve member 4 forward as shown in Figure 4, i.e. to the left of the position shown in each of Figures 1, 2 and 3, so that its front seating face engages the seating 26 in partition 27 and closes port 28. At the same time, the valve member 5 is driven forward by the front face 46 of the partition 7 of the valve member 4 to close off port 40.

Figure 5 shows a cross-section VV of a journal 62 and a bearing 63. The journal and bearing provide radial location for valve member 5 on spindle portion 11. The spindle portion 11 has a cross-section which has three equi-spaced longitudinal flats 64, i.e. so it is generally triangular but with the corners truncated to define curved bearing surfaces 65 matching the internal surface of bearing 63. Alternatively, instead of the flats 64 of the triangular spindle portion 11, the spindle portion 11 could have longitudinal grooves (not shown). The flats 64 or grooves (not shown) reduce the area of spindle portion 11 in contact with the inside surface of bearing 63 and their purpose is to improve the bearing's resistance to blockage and contamination.

Similarly, a bearing 66 is provided in the rear wall 44 of valve member 5 and the second portion 10 of spindle 9 is engaged in this bearing. The second portion 10 of spindle 9 has a cross-section defining flats or grooves the same as portion 11, i.e. the second portion 10 is also as shown in Figure 5.

Figure 6 shows a graph of variation with engine speed of air pressure from the lower and higher pressure compressor stages and the desired service pressure at the outlet port 29. The Roman numerals along the abcissa of Figure 6 (and in Figure 7 to be referred to later) mark values of engine speed when the valve member 5 is in the positions shown in Figures 1, 2 and 3 respectively.

It will be appreciated that instead of being as shown in Figure 6, it may be preferred for the service pressure requirement to rise with increasing engine speed in which case the valve flow areas between seating 41 and engaging portion 42 and between seating surface 30 and rear facing tapered corner 43 may be proportionately modified accordingly.

Figure 7 shows a graph illustrating a substantially constant mass flow of air available at the outlet port 29 as engine speed varies and the respective contributions of the mass flow from the two compressor stages. It will be appreciated that the relative contributions of mass flows through ports 28 and 40 may be adjusted by appropriate detailed modifications to the profiles 46 and 47. Further, it will be appreciated that a desired change from a constant mass flow rate available at the outlet port 29 with increasing engine speed to an increasing mass flow rate with increasing engine speed may be effected for example by increasing the flow area between the seating 30 and the rear facing tapered corner 43 when the valve is at a position corresponding to that illustrated in Figure 3.

ECD/JW/P03773GB
November 12, 2002

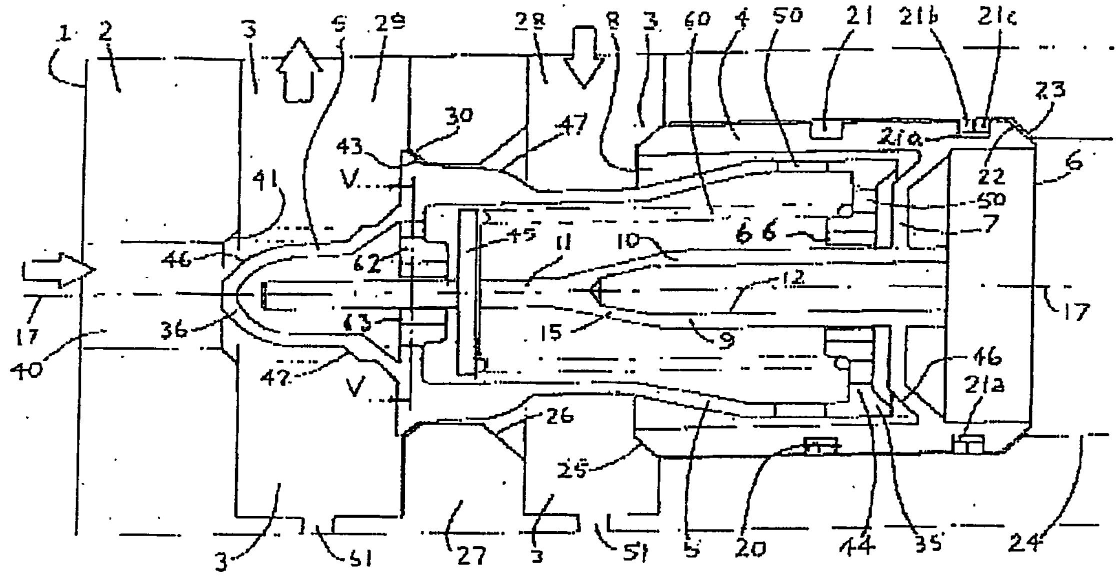

Fig 1

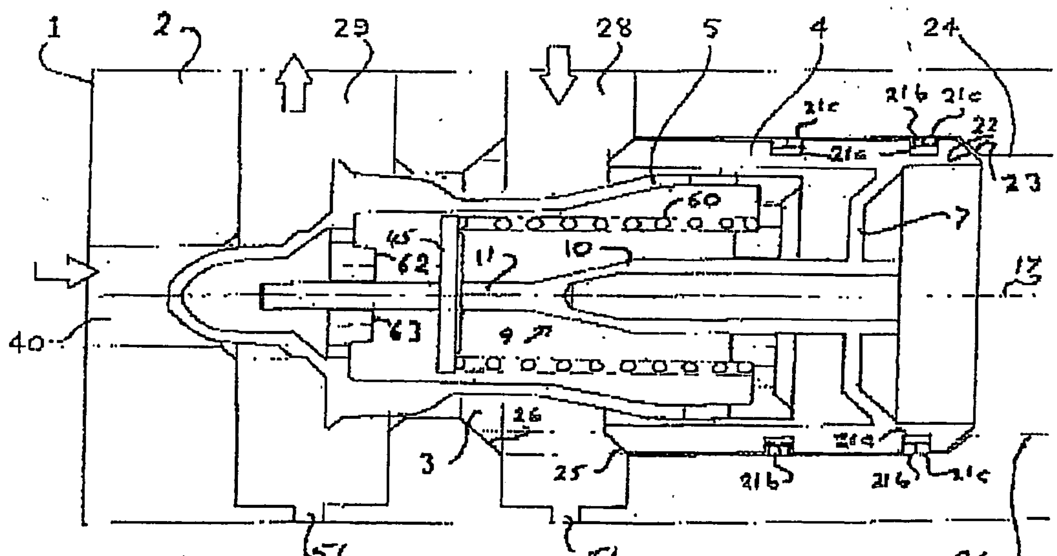

Fig 2

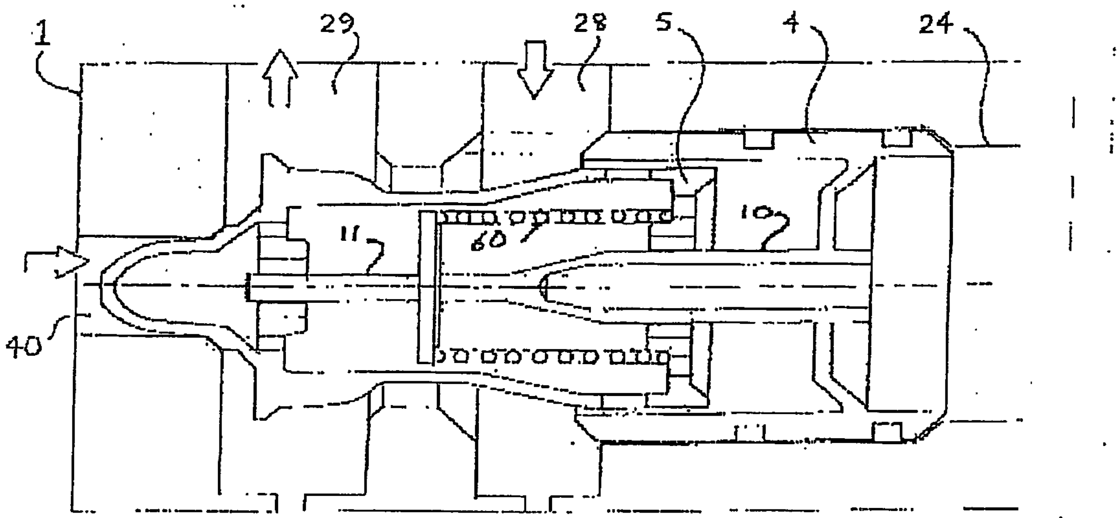

Fig 3

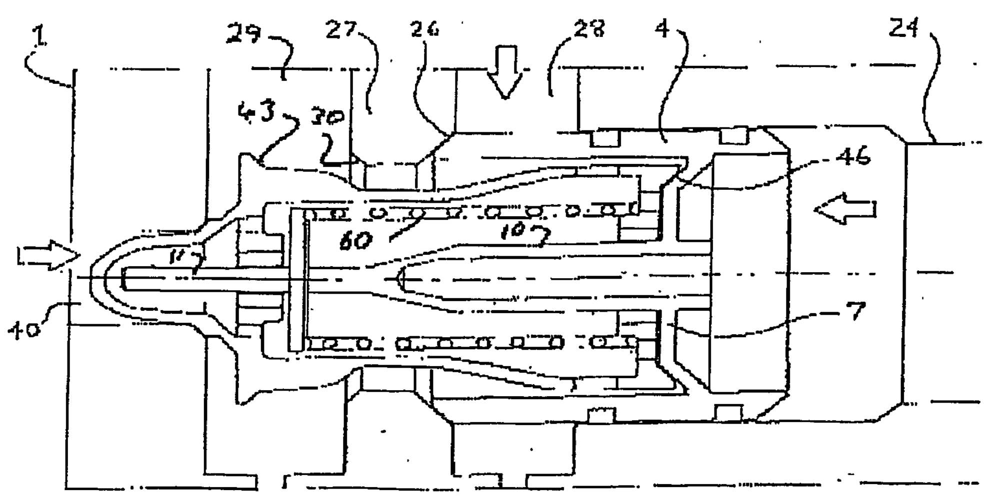

Fig 4

3/3

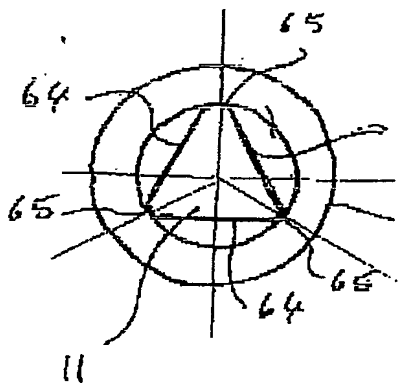

Fig 5

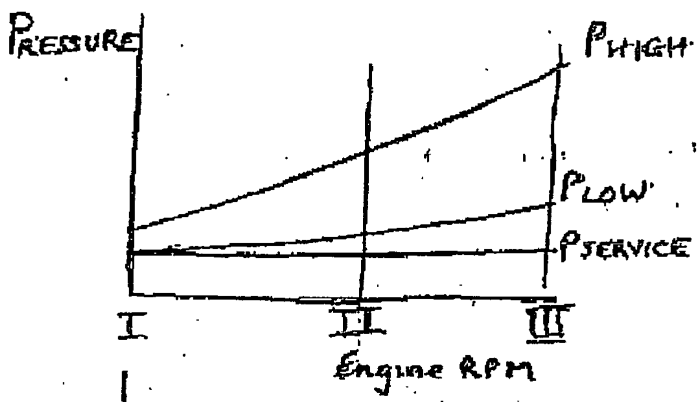

Fig 6

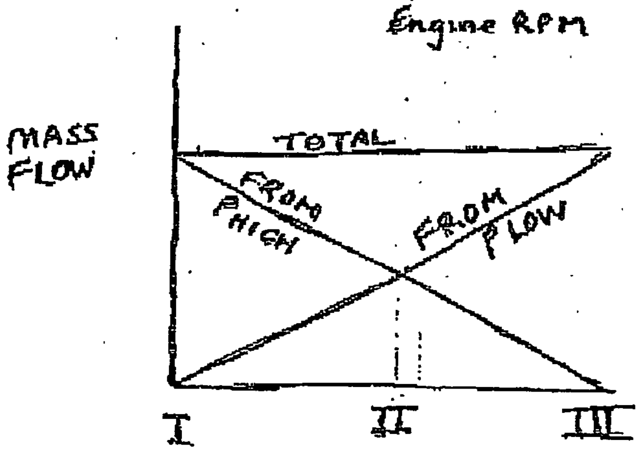

Fig 7.